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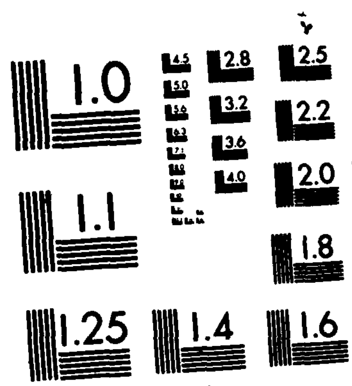

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PLASMA JOINING OF METAL MATRIX COMPOSITES

Submitted to U.S. Army Research Office

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Optical metallographic examinations of weld metal and heat affected zone microstructures of butt welds produced in 6061 Al-30% SiC composite plates using the low pressure, transferred arc plasma welding process with composite powder filler metals are described.

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ABSTRACT

Optical metallographic examinations of weld metal and heat affected zone microstructures of butt welds produced in 6061 Al-30% SiC_p composite plates using the low pressure, transferred arc plasma welding process with composite powder filler metals are described.

EXPERIMENTAL RESULTS

Previous reports described the microstructural and microchemical characterization of low pressure plasma-processed 1100 aluminum - 30 wt.% SiC_p, aluminum 5 - wt.% Ti - 30 wt.% SiC_p, and aluminum - 3 wt.% Zr - 30 wt.% SiC_p composite powders allowed to solidify in free flight or deposited onto inert substrates. This report describes the microstructures produced when these composite powders are deposited by the low pressure, transferred arc welding process into a 60° included angle, single bevel joint in 0.25 in. thick 6061 aluminum - 30 wt.% SiC_p composite base plates. Thus these are the first actual welds prepared with composite powder filler metals by the low pressure, transferred arc welding process. Plasma processing conditions were similar to those previously described with the imposition of a higher intensity transferred arc between the plasma torch and the 6061-30 SiC_p base metal plates to achieve significant melt-in of the base plate. The plates were mounted on the same water-cooled copper chill block used previously to cool inert stainless steel substrate plates. Thus the difference between procedures used to produce dense deposits on inert substrates and those used to produce butt welds in composite base plates is primarily the use of a more intense transferred arc in the latter case.

Figure 1. shows an optical micrograph (unetched) at 500X of the fusion line observed for the 6061-30SiC_p base plate welded with 1100 aluminum - 30 wt.% SiC_p composite filler metal. The base plate microstructure is at the lower left, the composite weld metal microstructure at the upper right, and the fusion line runnning from upper left to lower right. Several features are noteworthy. The fusion line is exceptionally clean and well bonded although a thin layer is seen to be free of SiC particulates. Microporosity is evident in both the weld metal and base metal heat affected zone microstructures (however in both cases it is no more severe than that observed in the as-received base metal). The weld metal can be seen to be uniformly reinforced with SiC and thus is a true composite weld metal as desired. This represents achievement of a major objective of the current program, the production of composite microstructures in fusion welds by the plasma welding technique.

Figures 2 and 3 show the weldment microstructures produced using aluminum - 5 wt.% Ti - 30 wt.% SiC_p and aluminum - 3 wt.% Zr - 30 wt.% SiC_p composite filler metals, respectivley. The weld metal, base metal and fusion line orientations are identical to those shown in Figure 1. Both weld metal microstructures are uniformly reinforced composites as desired. In both cases, the fusion line microstructure is clean and reinforced with SiC unlike that shown in Figure 1. The reason for incorporatiion of SiC in the fusion line microstructure when reactive metals are present in the filler metal matrix alloy composition is not yet known. Both weld metals shown in Figures 2 and 3 have reduced levels of microporosity compared to that observed in Figure 1. In all three photomicrographs, no obvious degradation of the base metal microstructure is observed near the fusion line, i.e. there is no classical, coarse-grained heat affected zone evident.

The filler metal compositions containing reactive metals appear to show exceptional promise for producing composite fusion welds in composite base plates. Microchemical characterizations of the matrix and reinforcing phases in the weld and base metals in the vicinity of the fusion line are in progress.

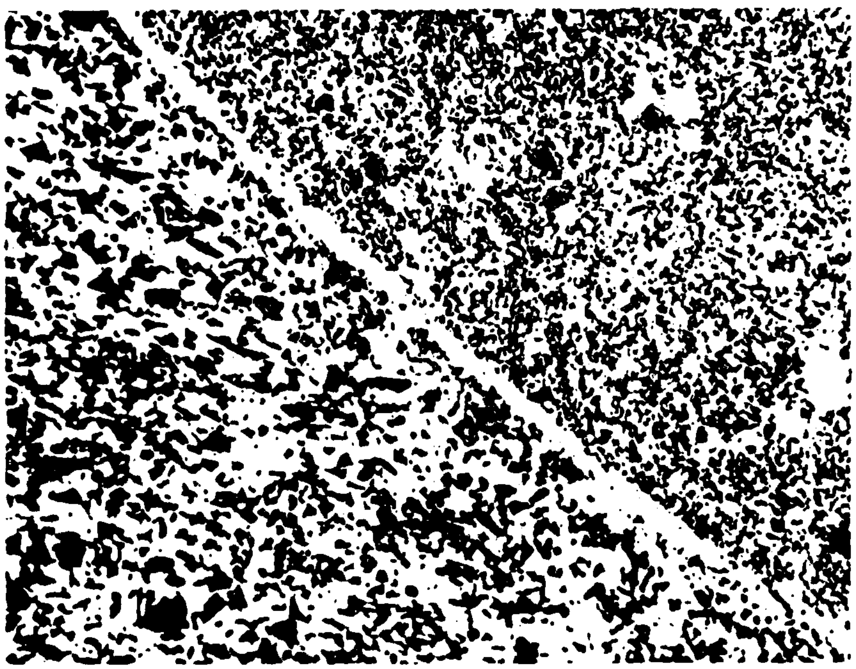

Figure 1. Optical micrograph of low pressure, transferred arc plasma weld produced using composite powder filler metals. Base metal (lower left) is 6061-30 wt.% SiC aluminum alloy. Weld metal (upper right) is 1100 aluminum -30 wt. % SiC. Fusion line extends from lower right to upper left. Note the metallurgical bond at the fusion line and the presence of an SiC-free zone at the fusion line. Magnification 500X.

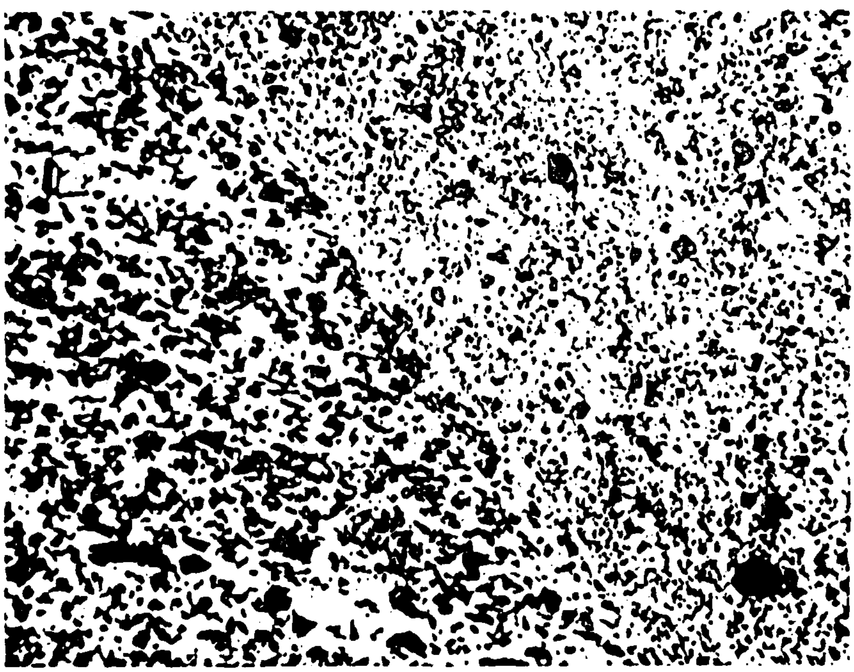

Figure 2. Optical micrograph of low pressure, transferred arc plasma weld produced using composite powder filler metals. Base metal (lower left) is 6061-30 wt.% SiC aluminum alloy. Weld metal (upper right) is aluminum - 5 wt.% titanium - 30 wt. % SiC. Fusion line extends from lower right to upper left. Note the metallurgical bond at the fusion line and the uniform distribution of SiC particulate phase both in the fusion line region and in the composite weld metal produced by this technique. Magnification 500X.

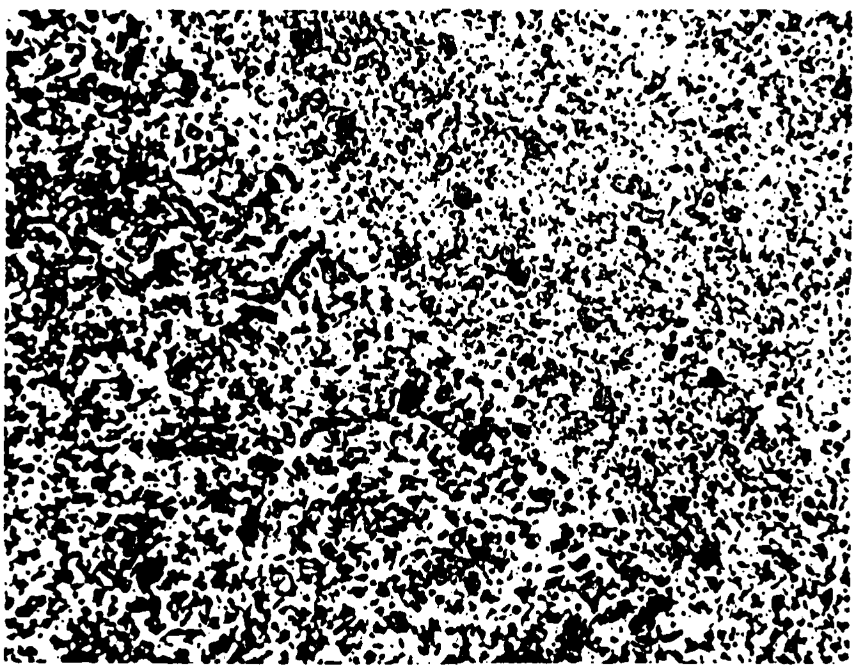

Figure 3. Optical micrograph of low pressure, transferred arc plasma weld produced using composite powder filler metals. Base metal (lower left) is 6061-30 wt.% SiC aluminum alloy. Weld metal (upper right) is aluminum - 3 wt.% zirconium - 30 wt. % SiC. Fusion line extends from lower right to upper left. Note the metallurgical bond at the fusion line and the uniform distribution of SiC particulate phase both in the fusion line region and in the composite weld metal produced by this technique. Magnification 500X.

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